Electronic Calibration Lab
7000 Franklin Blvd. #725
SACRAMENTO, CALIFORNIA 95823
(916) 392-5404

TO 33A1 2 30 1

INSTRUCTIONS
AND
PARTS LIST
FOR

HICKOK

PREAMPLIFIER

MODEL 1823A

HICKOK ELECTRICAL INSTRUMENT CO.
CLEVELAND, OHIO

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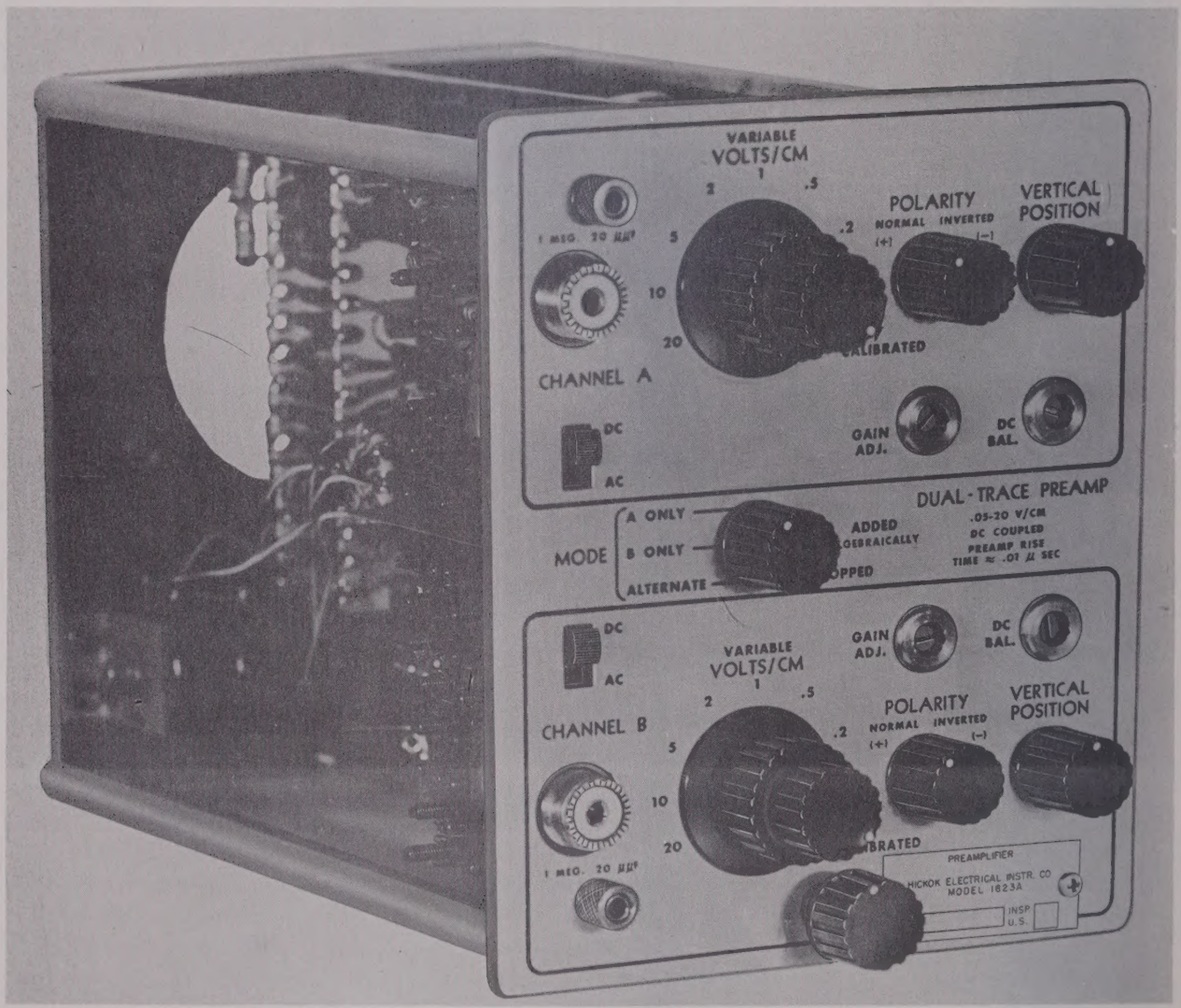


Figure 1-1. Identifying View of Model 1823A Preamplifier

SECTION I

USE AND MAINTENANCE

1. PURPOSE.

a. GENERAL. The Model 1823A plug-in-unit contains two identical amplifier channels which can be electronically switched, either by a free running rate of approximately 100 kc or by the oscilloscope sweep. When amplifier switching is triggered by the oscilloscope sweep, the two signals to be compared appear on alternate sweeps. Time comparisons accurate within 1 millimicrosecond can be made because the sweeps are identical and time-delay characteristics of the two amplifier channels are closely controlled.

Internal triggering of the sweep alternately by the two signals will give stationary display of the two signals unrelated in frequency. Switching occurs at a rate of approximately 100 kc in free running operation, permitting the operator to view two simultaneous transients. Transients of as little as one millisecond duration can be delineated, with about one hundred elements in each trace.

The Model 1823A plug-in-unit is useful in all single-trace applications, within its frequency-response and sensitivity capabilities, since either channel can be used separately without electronic switching. Each channel gives maximum flexibility by separate positioning, sensitivity and polarity-inverting controls. Adding or subtracting according to the settings of the polarity switches can be accomplished by placing the mode switch in the ADDED ALGERBRAICALLY position, combining the output of both channels. The Model 1823A is manufactured by the Hickok Electrical Instrument Co., Cleveland, Ohio. (See figure 1-1.)

2. QUICK REFERENCE DATA.

a. GENERAL. The power switch on the oscilloscope supplies power to both the oscilloscope and model 1823A preamplifier plug-in-unit, through an interconnecting receptacle in the preamplifier compartment.

CAUTION

Do not attempt to operate oscilloscope without preamplifier. Voltage regulation will be seriously altered.

b. Electrical characteristics. The Model 1823A plug-in-unit has nine calibrated sensitivities 0.05V/CM to 20 V/CM, accurate within 3% when set on any one step, on both channels A and B. The Unit has electronic switching at 100kc (chopped) and switching on alternate sweeps. Both channels are combined at output. (A ± B)

3. DESCRIPTION OF FRONT PANEL CONTROLS AND CONNECTORS AS SHOWN IN FIGURE 1-2.

1. CHANNEL A. CHANNEL B. Signal input of the A or B channel amplifier.

2. DC-AC. Slide switch to provide either AC or DC coupled input into the amplifier.

3. VOLTS/CM. Nine-position switch used to select the calibrated vertical-deflection sensitivities.

4. VARIABLE. Potentiometer concentric with the VOLTS/CM switch to provide continuously variable attenuation between the calibrated sensitivities and to extend the attenuation to a sensitivity of 50 V/CM.

5. POLARITY. Two position switch to provide optional in-phase or out-of-phase output.

6. VERTICAL POSITION. Potentiometer to provide for shifting the position of the trace vertically.

7. DC Bal. Screwdriver adjustable potentiometer

Type	Two channel dual trace
Number of tubes	15
Sensitivity	0.05 V/CM to 20 V/CM
Transient response risetime	0.01 microseconds
Input impedance	1 megohm 20uuf
Input	AC or DC
Weight	4 1/2 pounds

Table 1-1. Table of Specifications

TUBE DESIGNATION NUMBER	TUBE TYPE	FUNCTION
V801	12AT7	Switching multivibrator
V802	6AL5	Trigger coupling diode
V803	12AT7	Shaper
V804	12AT7	Switching cathode follower
V805, V810	6AK5	Input cathode follower
V806, V807 V811, V812	12AU6	Input amplifiers
V808, V809 V813, V814	6AU6	Output amplifiers
V815	12AT7	Output cathode follower

Table 1-2. Table of Electron Tube Complement

to provide for setting the VARIABLE attenuator DC levels so that the trace does not shift position when the attenuation is varied.

8. MODE. Five position switch to allow either amplifier to be used independently, to provide for switching the two amplifiers at an arbitrary rate, to synchronize the switching with the oscilloscope sweep, or to provide for adding the outputs of the amplifiers algebraically.

9. GAIN ADJ. Screwdriver adjustable potentiometer to permit the gain of the amplifier to be accurately set.

4. OPERATING INSTRUCTIONS.

a. FIRST TIME OPERATION.

(1) Plug the unit into an 1805-series oscilloscope and turn the power on. Allow the unit to reach operating temperature, about 2 to 3 minutes, and free-run the sweep at 1 millisecond/CM.

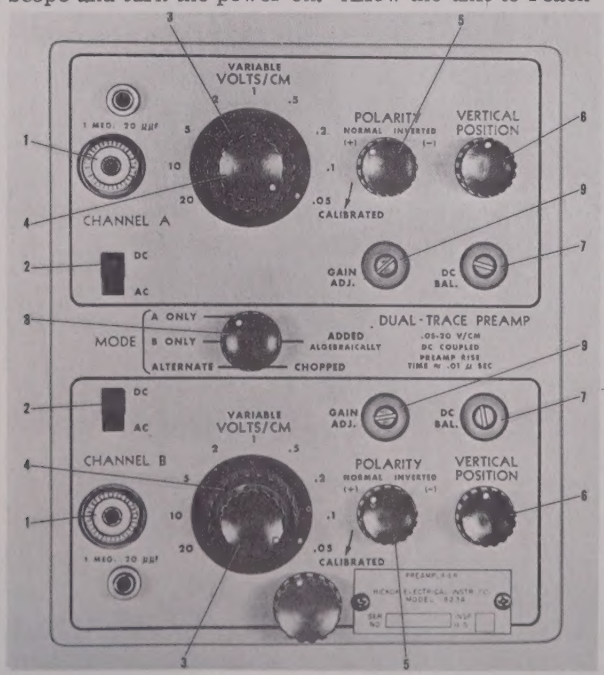


Figure 1-2. Front Panel Controls and Connectors

(2) Turn the MODE switch to A ONLY and the A channel POLARITY and AC-DC switches to NORMAL and DC respectively. Position the trace to about +2CM with the A-Channel VERTICAL POSITION control.

(3) Turn the MODE switch to B only and the B channel POLARITY and AC-DC switches to NORMAL and DC respectively. Position the trace to about -2CM with the B channel VERTICAL POSITION control.

(4) Now turn the MODE switch to CHOPPED. Two traces will appear on the CRT screen. Notice that the A-channel VERTICAL POSITION control moves the upper trace and the B-channel VERTICAL POSITION control moves the lower trace. Increase the sweep speed to 100 microsecond/CM and notice that each trace is composed of many short-duration elements. The two channels are being switched at approximately 100kc so that each channel conducts for about 5 USEC and then is cut off while the other channel conducts for an equal time.

(5) Now turn the MODE switch to the ALTERNATE position. There are still two traces on the CRT screen, but the traces are no longer chopped into small bits. For each sweep cycle one channel is conducting and the other is cut off. The channels are switched at the end of each sweep cycle.

b. GENERAL OPERATION. Either of the two amplified channels can be used independently by turning the MODE switch to A ONLY or B ONLY and connecting the signal to be observed to the appropriate input. The following instructions apply equally well to either amplifier channel.

1. USE OF PROBE. The probe furnished with the oscilloscope is designed to preserve the transient response of this unit. This probe introduces no ringing but causes an additional frequency response loss of less than 1db at 24MC. The probe has a 10-to-1 attenuation ratio.

Be sure to check the adjustment of the probe

before connecting it to the plug-in unit or oscilloscope. The probe compensation is a function of the shunt input capacitance of the preamplifier. If the compensation is incorrect, the frequency response will be affected. Touch the probe tip to the calibrator output connector on the oscilloscope and display several cycles of the calibrator waveform. If the top and bottom of the square wave are not flat, adjust the trimmer capacitor inside the probe body (or inside the box at the other end of the cable) to achieve correct squarewave response.

2. INPUT COUPLING. It is sometimes undesirable to display the DC level of the waveform being observed. Placing the AC-DC switch in the AC position inserts a capacitor in series with the input so the DC component of the waveform is blocked and only the AC component is displayed. The low-frequency response is about 2 CPS when AC coupling is used.

3. OUTPUT POLARITY. It will be desirable to invert the displayed waveform at times, particularly when using the dual-trace feature of the plug-in unit. The POLARITY switch has two positions. In the NORMAL position the displayed waveform will have the same polarity as the input signal. In the INVERTED position the displayed waveform will be turned upside down; that is, a positive-going pulse will be displayed as a negative-going pulse.

4. DC BALANCE ADJUSTMENT. After the plug-in unit has been in use for a period of time, the trace will change position as VARIABLE control is rotated. This is caused by tube aging and the resultant shift in operating potentials. To correct this condition, rotate the VARIABLE control back and forth and adjust the DC BAL control until the trace position is no longer affected by rotation of the VARIABLE control.

5. GAIN ADJUSTMENT. Aging of the tubes will also affect the gain of the plug-in unit. Display a calibrator waveform of 0.2 volt peak-to-peak with the VOLTS/CM switch in the .05 position. Adjust the GAIN ADJ control until the displayed waveform is 4 graticule divisions in amplitude. Make sure the VARIABLE CONTROL is turned full right to the CALIBRATED position before making this adjustment.

6. POSITIONING ADJUSTMENT. The full range of the front panel positioning controls can be utilized by the VERT POS RANGE control which balances the DC output level. The VERT POS RANGE control is only accessible when the left side panel is removed. Center the trace in both the A ONLY and B ONLY positions of the MODE switch. Note the settings of the VERTICAL POSITION controls. Adjust the VERT POS RANGE control to bring both A and B channel VERTICAL POSITION controls to approximately center when the displayed trace is centered.

c. SPECIFIC OPERATION.

1. GENERAL. The observation of repetitive waveforms, observation of single transients, and observation of one waveform superimposed upon another can be performed with the Model 1823A plug-in unit. These will be discussed in the order stated, as they are fundamentally different.

2. REPETITIVE SIGNALS. Connect the two signals to be compared to the two signal inputs and turn the MODE switch to A ONLY. To display waveform, set the sweep up for triggered operation and adjust the VOLTS/CM and VERTICAL POSITION controls as necessary. To display the other waveform, turn MODE switch to B ONLY and adjust the corresponding controls as necessary. Turn MODE switch to ALTERNATE. Touch up oscilloscope sweep triggering controls, if necessary, to obtain a stable image. Both waveforms should now be displayed on the screen. Since control of each amplifier is independent, the signals can be positioned, attenuated, or inverted as necessary to compare their shape, relative amplitudes, etc. Use the AC FAST triggering mode and ALTERNATE sweeps for internal triggering on signals having components above 10 kc. For lower frequency signals, use the AC SLOW triggering mode. In the AC FAST position, an RC filter is inserted into the circuit allowing it to recover quickly from the DC level changes encountered with the ALTERNATE sweep. To compare the phase difference between two signals, trigger externally using the reference signals as the trigger signal.

3. SINGLE TRANSIENTS. Another procedure must be followed when it is necessary to observe a single transient at two parts of a circuit. In the previous procedure, one of the signals triggers the sweep and that amplifier remains conducting for the sweep duration. Amplifiers are switched at the end of the sweep, and the other signal then triggers the sweep and that amplifier remains conducting for the sweep duration. Each of the signals is being displayed every other sweep cycle. To observe a single transient in this manner the transient will pass through whichever amplifier happens to be conducting and will trigger the sweep. This will display the transient as seen by whichever amplifier is conducting but when the amplifiers are switched at the end of the sweep there will be no further signal to trigger another sweep until the next transient occurs. It is, therefore, preferable to observe the transient using both amplifiers during a single sweep cycle. Turn the MODE switch to CHOPPED. The two amplifiers are now being switched on and off independently of any signal. The switching rate is approximately 100 kc so each amplifier is conducting for about 5 microseconds and then is cut off while the other amplifier conducts for an equal length of time. In this case the sweep is being triggered by the switching waveform, particularly if the two traces are positioned very far apart, it will usually be very difficult, if not impossible, to trigger the sweep internally from the signal as the switching waveform is equivalent to a 100 kc square wave. Therefore, the sweep controls should be set for external triggering. Proper procedure for external triggering of the sweep is covered in operating instructions section of the oscilloscope manual.

Now the two signals to be observed can be connected to the two inputs and both waveforms will be

displayed during one sweep cycle. Transients as short as 1MSEC duration can be well delineated with about 100 elements in each trace. As before, the independent control of each amplifier permits the waveforms to be positioned, attenuated, or inverted so they can be easily compared.

4. ALGEBRAIC ADDITION. In many applications the desired signal is superimposed on an undesired signal such as line frequency hum, etc. It is possible in many cases to improve the ratio of desired to undesired signals, with the Algebraic output of the Model 1823A unit (with the MODE switch in ADDED ALGEBRAICALLY position). Connect one input to a source containing both the desired and undesired signals. Connect the remaining input to a source containing only the undesired signal. Place the MODE switch in the ADDED ALGEBRAICALLY position. Set the POLARITY switches to opposite polarities (depending upon the polarity of the desired signal).

By careful adjustment, especially at low frequencies, of the VARIABLE controls and/or the GAIN ADJ controls, the amplitude of the undesired signal displayed can be reduced by a factor of 20 compared to the amplitude of the desired signal.

5. CIRCUIT DESCRIPTION.

a. GENERAL. The Model 1823A plug-in unit consists of two identical amplifier channels and a channel switching multivibrator. The following description of amplifiers applies equally well to either channel.

b. INPUT COUPLING AND ATTENUATION. The signal to be displayed is applied to the input cathode follower V805 (V810) by way of the AC-DC switch and the VOLTS/CM switch. The AC-DC switch is a two position slide switch that bypasses C864 (C865) in the DC position so that the input is DC-coupled. In the AC position of this switch the signal must pass through C864 (C865) so the DC component of the signal is blocked. The VOLTS/CM switch is a 9-position rotary switch that selects the various frequency-compensated RC attenuator section. The sensitivity of the unit is .05 VOLTS/CM. The input voltage is reduced by the eight individually selected attenuator sections to give nine fixed calibrated ranges.

c. INPUT STAGE. The input stage consists of the cathode follower V805 (V810) and the cathode-coupled phase inverters V806 and V807 (V811 and V812). The control-grid DC level of V806 (V811) is established by the DC connection to the cathode of V805 (V810). The control grid DC level of V807 (V812) is adjustable by means of the DC BAL control so that the DC level of the cathodes of V806 and V807 (V811 and V812) can be made equal. Any DC level difference between these two cathodes would act as a signal and cause the trace to shift position when the VARIABLE control is rotated. The VARIABLE gain control establishes the amount of cathode coupling and thus allows the stage gain to be varied over about a 2 1/2 to 1 range. The GAIN ADJ control permits the basic gain of the unit to be accurately set to agree with the front-panel calibration.

d. POLARITY AND POSITIONING. With the POLARITY switch to the NORMAL position the displayed waveform will have the same polarity as the input signal. Placing the POLARITY switch in the INVERTED position reverses the signal-grid connection of V808 and V809 (V813 and V814) and inverts the displayed waveform. Rotation of the VERTICAL POSITION control forces one plate of the input stage towards a higher potential and the opposite plate towards a lower potential. The resulting DC level shift moves the trace vertically.

e. AMPLIFIER STAGE AND OUTPUT CF. The signal is further amplified by V808 and V809 or V813 and V814, depending on which channel is conducting. V808 and V813 have a common plate load, as do V809 and V814. Since one amplifier is always cut off while the other is conducting, the shunt loading effect is negligible. V815 is the output cathode follower that provides a low-impedance source for driving the oscilloscope vertical amplifier. The VERT. POS. RANGE control located in the grid circuit of the output CF permits the trace to be centered vertically under no-signal conditions.

f. SWITCHING CIRCUIT.

(1) A ONLY, B ONLY. V801 is a multivibrator that is controlled by the MODE switch. In the A ONLY or B ONLY position, the multivibrator is held in one of its two possible states by returning one grid to a positive voltage and the other grid to a negative voltage. For example, in the A ONLY position the grid of V801A is held positive and this half of the multivibrator conducts while the grid of V801B is held negative and this half is cut off. While V801A is conducting, the cathode is above ground which causes V803B to conduct and in turn pulls the grid of V804B toward ground, lowering the plate voltage of V811 and V812. This reduced plate voltage cuts off the following stage (V813 and V814) and the B-channel amplifier is held in a non-conducting state. The converse is true of the A-channel amplifier. The grid of V803A is near ground potential and with reduced plate current the plate of V803A and consequently the grid of V804A are permitted to become more positive, providing plate voltage for V806 and V807 and the A-channel amplifier then conducts.

(2) CHOPPED. Turning the MODE switch to the CHOPPED position returns both grids of the multivibrator to a positive voltage and the multivibrator free-runs at a rate determined by the time constant of the grid circuits. The two amplifiers are alternately cut off and allowed to conduct at the free-running rate of the multivibrator.

(3) ALTERNATE. Turning the MODE switch to the ALTERNATE position returns both grids of the multivibrator to a negative potential and it is then bistable. At the end of each sweep cycle a negative-going trigger is generated and is coupled to the multivibrator through the trigger coupling diode V802. Each trigger causes the multivibrator to "flip" from one stable state to the other. This alternately switches the amplifier on and off but now the switching rate is

determined by the repetition rate.

(4) ADDED ALGEBRAICALLY. Turning the MODE switch to the ADDED ALGEBRAICALLY position returns both grids of the multivibrator to -150 volts. Both sides of multivibrator (V801) are held sufficiently negative so that incoming triggers have no effect on the multivibrator grids. The cathodes of both halves of the multivibrator follow the grids down, driving V803A and V803B to cut off. With V803A and V803B cut off, the plate voltage rises, carrying the grids of the following stage V804A and V804B with it. The cathodes of V804A and V804B follow the grids up. Plate voltage for the input amplifier stages of both channels is supplied by the cathodes of either V804A or V804B. When the cathodes are up, both amplifier channels conduct equally in the absence of any signal. Under the conditions described above, signals applied to both inputs will be amplified equally by either channel. Algebraic addition of the signal occurs at the grids of the output stage, V815. In-phase input signals add, out-of-phase input signals substract, at the grid of each tube if the polarity switches are at the same setting.

6. MAINTENANCE INSTRUCTIONS.

a. GENERAL. Ordinarily, adjustment in the field will consist of merely touching up some of the DC level and balance controls, as described in paragraph 4. However, if a complete readjustment of the transient response is necessary the sequence of adjustment outlined in the following paragraphs should be followed. Trouble shooting points are outlined in table 1-3.

b. To make the following adjustments, you will need to do one of three things to preserve the input capacitance of the unit which is accurately set to 20 μμf at the factory. This adjustment ensures that a properly adjusted probe can be used interchangeably with other units having 20μμf input capacitance. (1) Use a 20 μμf input-capacitance standardizer; (2) calibrate a probe against a plug-in unit known to be in correct adjustment; or (3) measure the input capacitance with a Type 130 L-C meter or with a capacitance bridge.

7. OPERATIONAL ADJUSTMENTS.

a. PEAKING COILS. Set all peaking-coil slugs so that the top of each slug is flush with the bottom turn of the winding, as preliminary adjustment. (These settings alone are adequate for approximately correct results, for emergency purposes). For complete calibration of the peaking coils, plug the unit into an oscilloscope known to be in correct adjustment. Side panels or cabinet must be removed. A source of square waves or pulses having a rise time not longer than 3 millimicroseconds is needed. The repetition rate should be 1 kc or more. It is essential that this source be terminated in accordance with the manufacturer's specifications.

Turn the MODE switch to A ONLY, the VOLTS/CM switch to 0.05, and the VARIABLE control full right to CALIBRATED position. The peaking coils should be adjusted for a square corner with no overshoot, as they affect the rise and leading corner of the square waves.

1. ADJUST L817 and L818.
2. ADJUST L807 and L808.
3. ADJUST L801 and L802.

Move the square-wave source to the channel B input connector and set the B channel controls in the same manner as the A channel controls.

1. ADJUST L815 and L816.
2. ADJUST L809 and L810.

If, after adjustment, one channel seems to have a better response, try a slightly different setting of L817 and L818 which are common to both channels. Repeat steps 2 and 3 of the A-channel adjustments and steps 1 and 2 of the B-channel adjustment. Experiment as necessary with the settings of L817 and L818 to find which setting will give the best balance of response. Repeat steps 2 and 3 of the A-channel adjustments and steps 1 and 2 of the B-channel adjustment after each setting of L817 and L818.

b. INPUT ATTENUATORS. There are two types of adjustment to be made, requiring a square-wave source having a rise time not longer than 0.025 microseconds. The source must be terminated according to the manufacturer's specification. To compensate the attenuators so that the AC attenuation is equal to the DC attenuation, one type of adjustment is made involving a moderately short time constant. A slight rounding or overshoot at the leading corner of the square wave can be recognized as misadjustment. The other type of adjustment is made to get equal input capacitances at all positions of the attenuator. Misadjustments can be recognized by using a Type 130 L-C meter.

First compensate the A-channel attenuators. Connect a 20 μμf input-capacitance standardizer to channel A input connector and connect the square wave source to the standardizer. Display four or five cycles of a 1 kc square wave. Set the VOLTS/CM switch to .05 and adjust C867 for a flat top square wave. Remove the standardizer and connect the square-wave source to the input connector. Adjust the listed capacitors for a square corner on the square wave.

VOLTS/CM	CAPACITOR
.1	C803
.2	C806
.5	C810
1	C814
2	C817
5	C822
10	C826
20	C830

Connect the standardizer to the channel A input connector and connect the square-wave source to the standardizer.

Adjust the input capacitance with VOLTS/CM switch in positions shown:

VOLTS/CM	CAPACITOR
.1	C802
.2	C805
.5	C809
1	C813
2	C816
5	C821
10	C825
20	C829

Repeat the above operations with the B-channel amplifier. Move the square wave source to the channel B input connector with the standardizer in place, and adjust C877 for a flat top on the square wave. The VOLTS/CM switch should be in the 0.05 position. Remove the standardizer and compensate the attenuator.

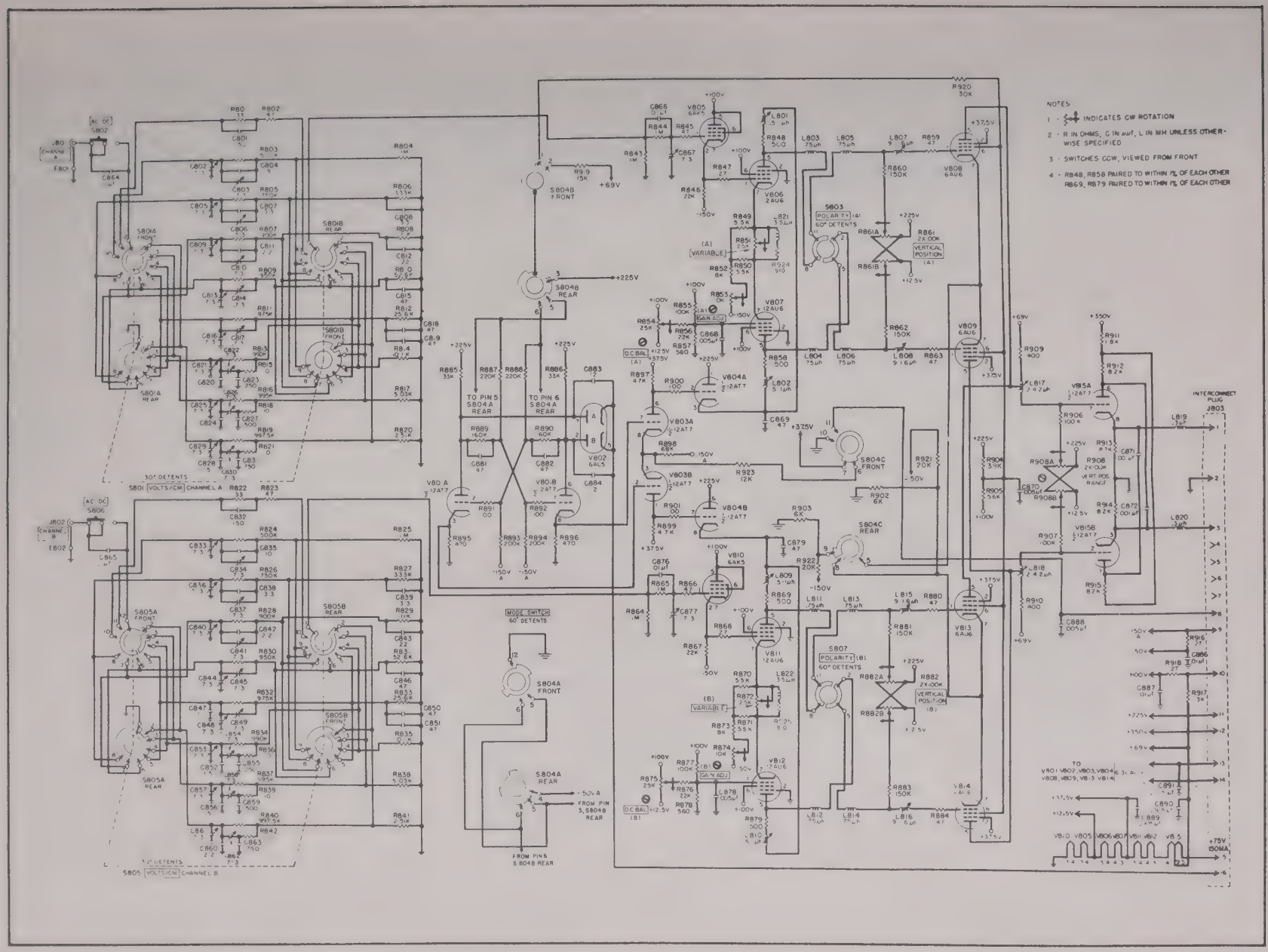
VOLTS/CM	CAPACITOR
.1	C834
.2	C837
.5	C841
1	C845
2	C849
5	C854
10	C858
20	C862

Insert the standardizer and adjust the input capacitance:

VOLTS/CM	CAPACITOR
.1	C833
.2	C836
.5	C840
1	C844
2	C848
5	C853
10	C857
20	C861

TROUBLE	PROBABLE CAUSE	REMEDY
Trace cannot be centered vertically.	Vertical position range control out of adjustment.	Adjust control (par. 4b (6)).
	Defective cathode follower output tube.	Replace V815 tube.
	Defective output amplifiers.	Replace V808, V809, V813 and/or V814.
	DC BALANCE CONTROL out of adjustment.	Adjust R854 and R875 (par. 4b (4)).
	Defective input amplifiers.	Replace V806, V807, V811 and/or V812.
	Defective input cathode follower.	Replace V805 and/or V810.
Switching circuit not operating properly.	Defective tubes.	Replace V801, V803, and/or V804.
Unit not operating properly with mode switch in alternate position.	Defective trigger coupling diode.	Replace V802.
Unit not operating properly with mode switch in added algebraically.	"GAIN ADJ." control out of adjustment.	Adjust "GAIN ADJ." control (par. 4b (5)).

Table 1-3. Trouble Shooting


NOTES
1 - INDICATES CW ROTATION
2 - R IN OHMS, C IN μμf, L IN MH UNLESS OTHERWISE SPECIFIED
3 - SWITCHES CCW, VIEWED FROM FRONT
4 - R848, R858 PAIRED TO WITHIN 1% OF EACH OTHER
R869, R879 PAIRED TO WITHIN 1% OF EACH OTHER
S801 VOLTS/CM CHANNEL A
S805 VOLTS/CM CHANNEL B
MODE SWITCH
INTERCONNECT PLUG J803
TO V801, V802, V803, V804, V808, V809, V813, V814
+75V 150MA

SECTION II

PARTS BREAKDOWN

1. GENERAL. This section lists the parts of the preamplifier Model 1823A in alpha-numerical order according to reference symbols. Figures 2-1 through 2-5 illustrate the physical location of parts in the equipment. The parts are called out on the illustration by reference designator which correspond with the replacement parts list and the schematic.

2. USE OF REPLACEMENT PARTS LIST.

a. FINDING PART NUMBER AND DESCRIPTION. When reference symbol or part number is unknown and a replacement part is required, identify part on applicable illustration in section II.

b. Locate reference symbol number, assigned to part "REF. SYMBOL" column of replacement parts list. Part number is listed opposite reference symbol in "Part Number" column. "Description" column contains identifying characteristic nomenclature.

c. FINDING APPLICABLE ILLUSTRATION AND DESCRIPTION. When reference symbol is known but physical location is unknown, find reference symbol in replacement parts. Figure number on which part is shown is listed in "Located on Figure No." column.

3. REPLACEMENT PARTS. All replacement parts may be purchased from Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland 8, Ohio.

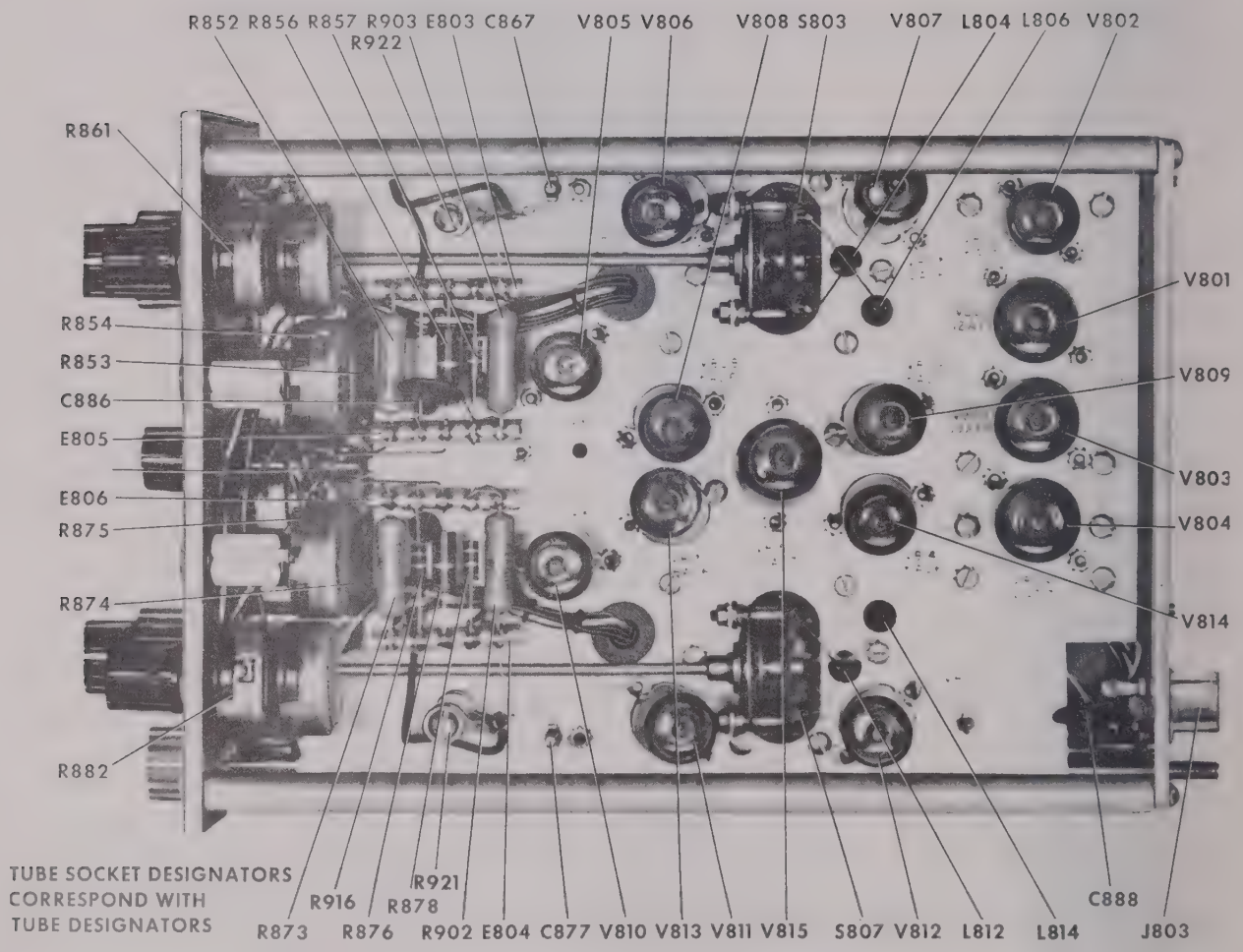


Figure 2-1. Preamplifier - Left Side View

REF. SYMBOL	PART NUMBER	DESCRIPTION	QUANT. PER EQUIP.	LOCATED ON FIGURE NO.
C801	3110-100	CAPACITOR, FIXED, CERAMIC, 150 uuf ±20% 500V	2	2-5
C802	3115-25	CAPACITOR, VARIABLE, CERAMIC, 0.7 to 3.0 uuf, tubular, 500V	34	2-3
C803		Same as C802		2-3
C804	3110-88	CAPACITOR, FIXED, CERAMIC, 8 uuf±0.5 uuf, 500V	1	2-4
C805		Same as C802		2-3
C806		Same as C802		2-3
C807	3110-86	CAPACITOR, FIXED, CERAMIC, 3.3 uuf±1/4 uuf, 500V	4	2-4
C808		Same as C807		2-5
C809		Same as C802		2-3
C810		Same as C802		2-3
C811	3110-103	CAPACITOR, FIXED, CERAMIC, 2.2 uuf±0.5 uuf, 500V	3	2-4
C812	3110-92	CAPACITOR, FIXED, CERAMIC, 22 uuf ± 10%, 500V	2	2-5
C813		Same as C802		2-3
C814		Same as C802		2-3
C815	3110-98	CAPACITOR, FIXED, CERAMIC, 47 uuf ± 10% 500V	8	2-4
C816		Same as C802		2-3
C817		Same as C802		2-3
C818		Same as C815		2-4
C819		Same as C815		2-4
C820	3110-105	CAPACITOR, FIXED, CERAMIC, 1.0 uuf ± 0.2 uuf, 500V, insulated type	3	2-4
C821		Same as C802		2-3
C822		Same as C802		2-3
C823	3095-105	CAPACITOR, FIXED, MICA, 250 uuf ± 10% 500 volts	2	2-4
C824		Same as C820		2-4
C825		Same as C802		2-3
C826		Same as C802		2-3
C827	3095-106	CAPACITOR, FIXED, MICA, 500 uuf ± 10% 500 volts	2	2-4
C828	3110-102	CAPACITOR, FIXED, CERAMIC, 1.5 uuf ± 1/2 uuf, 500V	3	2-4

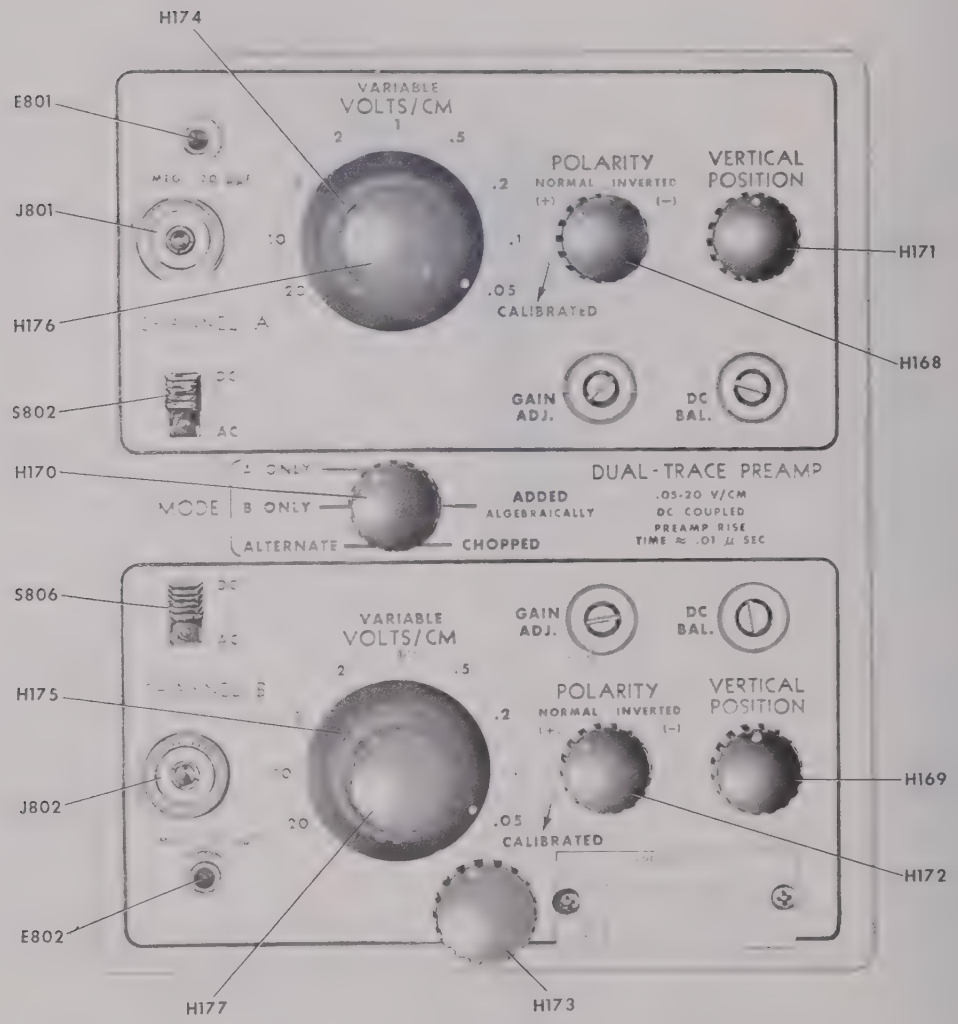


Figure 2-2. Preamplifier - Front Panel

REF. SYMBOL	PART NUMBER	DESCRIPTION	QUANT. PER EQUIP.	LOCATED ON FIGURE NO.
C829		Same as C802		2-3
C830		Same as C802		2-3
C831	3095-107	CAPACITOR, FIXED, MICA, 750 uuf ±10%, 500 volts	2	2-4
C832		Same as C801		2-5
C833		Same as C802		2-3
C834		Same as C802		2-3
C835	3110-89	CAPACITOR, FIXED, CERAMIC, 10 uuf ±10%, 500V	1	2-4
C836		Same as C802		2-3
C837		Same as C802		2-3
C838		Same as C807		2-4
C839		Same as C807		2-5
C840		Same as C802		2-3
C841		Same as C802		2-3
C842		Same as C811		2-4
C843		Same as C812		2-5
C844		Same as C802		2-3
C845		Same as C802		2-3
C846		Same as C815		2-4
C847		Same as C820		2-4
C848		Same as C802		2-3
C849		Same as C802		2-3
C850		Same as C815		2-4
C851		Same as C815		2-4
C852		Same as C828		2-4
C853		Same as C802		2-3
C854		Same as C802		2-3
C855		Same as C823		2-4
C856		Same as C828		2-4
C857		Same as C802		2-3
C858		Same as C802		2-3
C859		Same as C827		2-4
C860		Same as C811		2-4

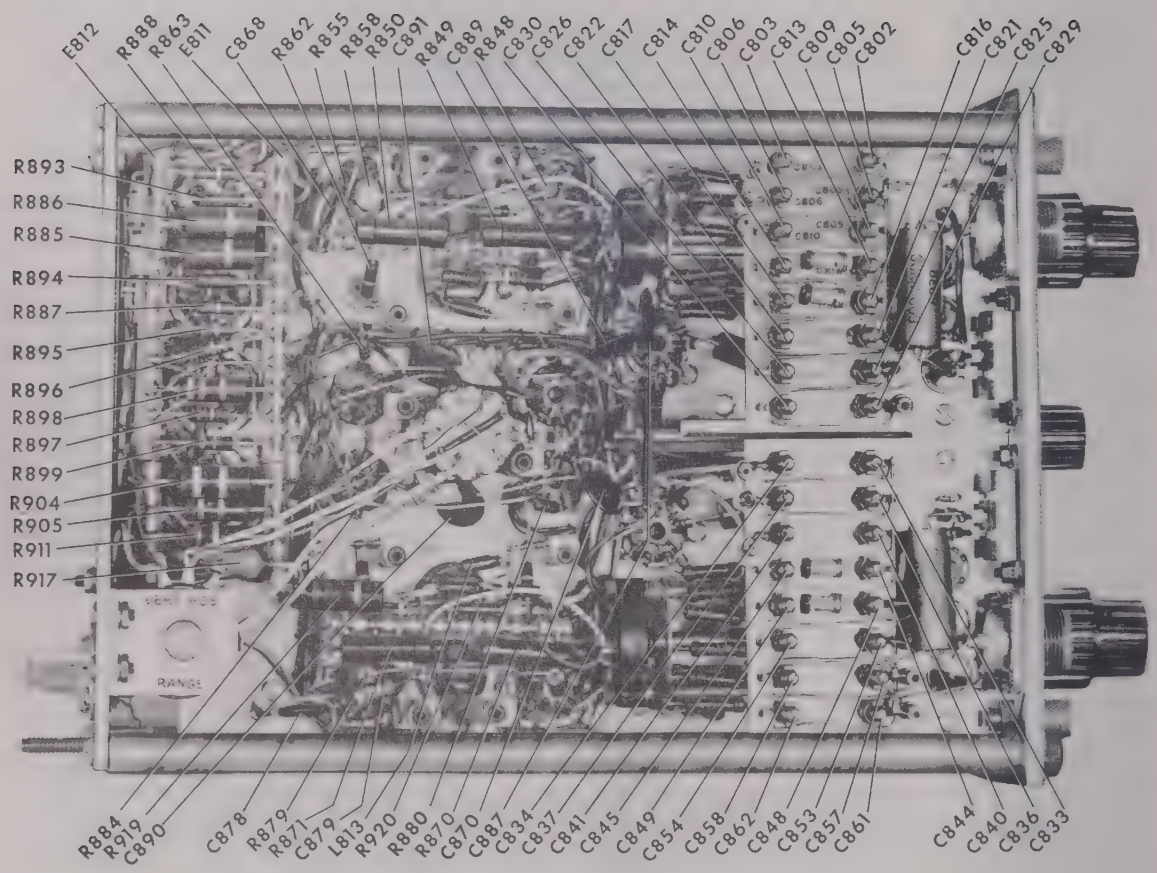


Figure 2-3. Preamplifier - Right Side View

REF. SYMBOL	PART NUMBER	DESCRIPTION	QUANT. PER EQUIP.	LOCATED ON FIGURE NO.
C861		Same as C802		2-3
C862		Same as C802		2-3
C863		Same as C831		2-4
C864	3105-245	CAPACITOR, FIXED, PAPER, 0.1 uf, ± 20%, 600V., tubular	2	2-4
C865		Same as C864		2-4
C866	3110-109	CAPACITOR, FIXED, 0.01 uf, 150V, disc type	2	2-5
C867		Same as C802		2-1
C868	3110-65	CAPACITOR, FIXED, CERAMIC, 4700 uuf, 500V., +100-20%, disc type	7	2-3
C869	3110-97	CAPACITOR, FIXED, CERAMIC, 47 uuf ± 10%, 500V	2	2-4
C870		Same as C868		2-3
C871	3110-107	CAPACITOR, FIXED, CERAMIC, 0.001 uf, GMV, disc type	2	2-5
C872		Same as C871		2-5
C873		Not assigned		
C874		Not assigned		
C875		Not assigned		
C876		Same as C866		2-5
C877		Same as C802		2-1
C878		Same as C868		2-3
C879		Same as C869		2-3
C880		Not assigned		
C881		Same as C815		2-4
C882		Same as C815		2-4
C883	3110-90	CAPACITOR, FIXED, CERAMIC, 12 uuf ± 10%, 500V	2	2-4
C884		Same as C883		2-4
C885		Not assigned		
C886	3110-64	CAPACITOR, FIXED, CERAMIC, 0.01 uf, 500V., +100 -20%, disc type	2	2-1
C887		Same as C886		2-3
C888		Same as C868		2-1
C889		Same as C868		2-3

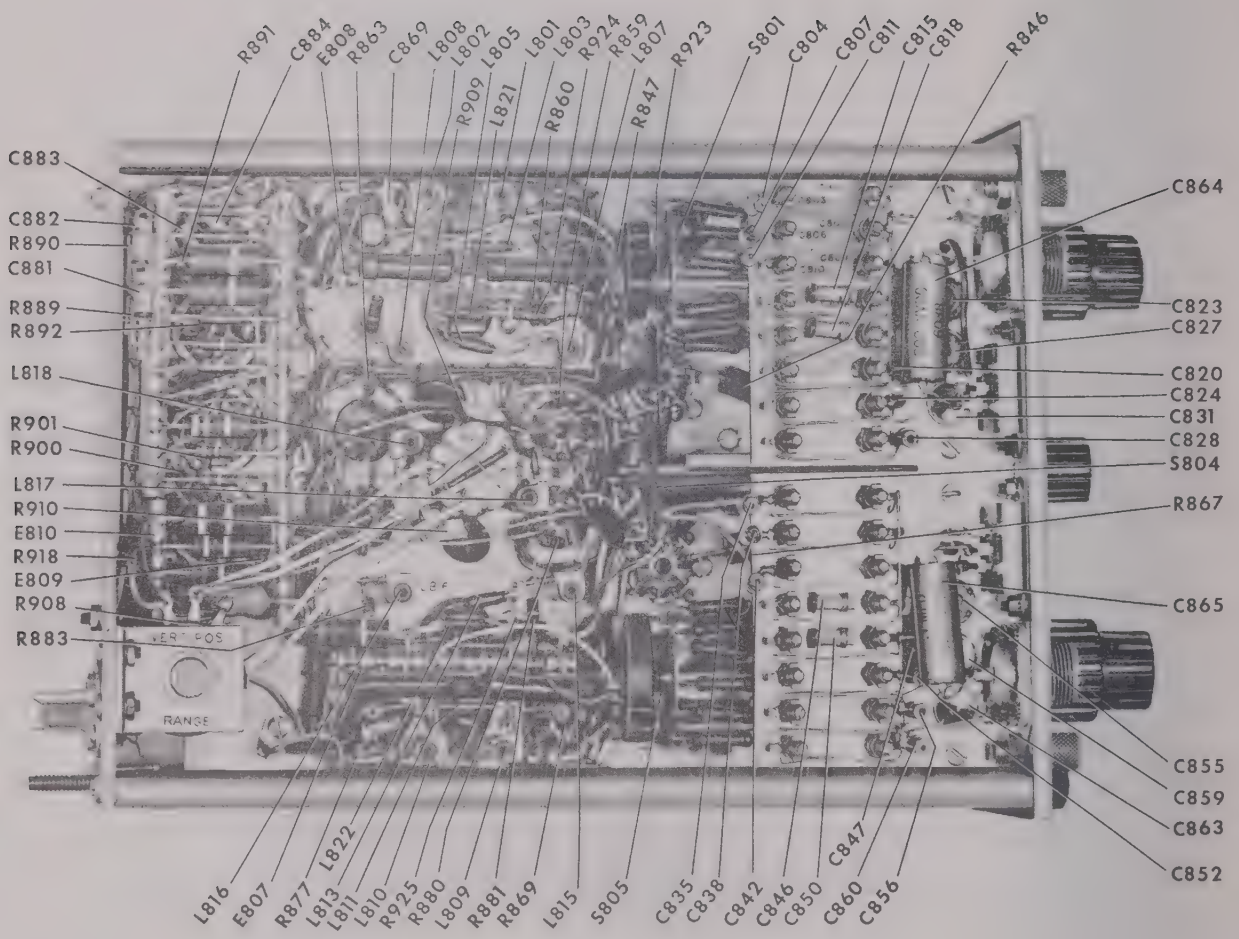


Figure 2-4. Preamplifier - Right Side View

REF. SYMBOL	PART NUMBER	DESCRIPTION	QUANT. PER EQUIP.	LOCATED ON FIGURE NO.
C890		Same as C868		2-3
C891		Same as C868		2-3
E801	2360-86	BINDING POST	2	2-2
E802		Same as E801		2-2
E803	20352-305	TERMINAL STRIP, 5 notch	4	2-1
E804		Same as E803		2-1
E805		Same as E803		2-1
E806		Same as E803		2-1
E807	20352-109	TERMINAL STRIP, 9 notch	2	2-4
E808		Same as E807		2-4
E809	20352-204	TERMINAL STRIP ASSY, 4 notch	2	2-4
E810		Same as E809		2-4
E811	20352-211	TERMINAL STRIP ASSY, 11 notch	2	2-3
E812		Same as E811		2-3
E813	20352-1	TERMINAL STRIP ASSEMBLY	1	2-5
H168	11505-86	KNOB, black, small, shaft hole size 0.128 dia, plastic	2	2-2
H169		Same as H168		2-2
H170	11505-87	KNOB, black, small, shaft hole size 0.253 dia, plastic	3	2-2
H171		Same as H170		2-2
H172		Same as H170		2-2
H173	11505-89	KNOB, gray, shaft hole size 0.190 dia, plastic	1	2-2
H174	11505-90	KNOB, black, large shaft hole size 0.253 dia drill thru	2	2-2
H175		Same as H174		2-2
H176	11505-94	KNOB, red large, shaft hole size 0.125 dia, plastic	2	2-2
H177		Same as H176		2-2
J801	3475-84	CONNECTOR, RF, teflon filled, female	2	2-2
J802		Same as J801		2-2
J803	16525-162	PLUG, 16 contacts	1	2-1
L801	3320-149	COIL, VARIABLE, 1.1 uh-1.7 uh	4	2-4
L802		Same as L801		2-4
L803	3320-144	COIL, FIXED, 0.75 uh	8	2-4
L804		Same as L803		2-1

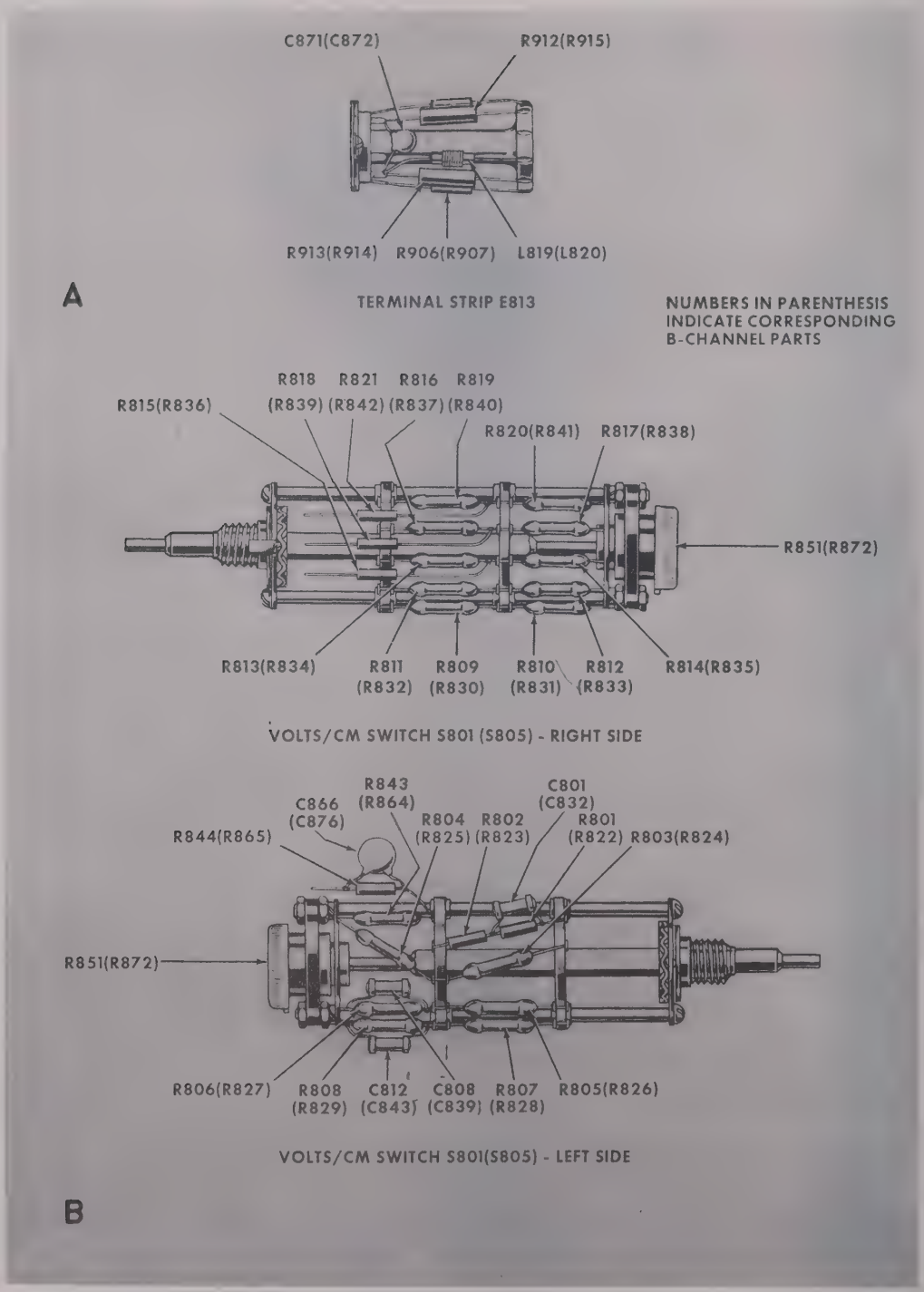


Figure 2-5. Preamplifier - Terminal Strip E813 and Volts/CM Switch

REF. SYMBOL	PART NUMBER	DESCRIPTION	QUANT. PER EQUIP.	LOCATED ON FIGURE NO.
L805		Same as L803		2-4
L806		Same as L803		2-1
L807	3320-151	COIL, VARIABLE, 0.9-1.5 uh	4	2-4
L808		Same as L807		2-4
L809		Same as L801		2-4
L810		Same as L801		2-4
L811		Same as L803		2-3
L812		Same as L803		2-1
L813		Same as L803		2-3
L814		Same as L803		2-1
L815		Same as L807		2-4
L816		Same as L807		2-4
L817	3320-156	COIL, VARIABLE, 2 uh-3.7 uh	2	2-4
L818		Same as L817		2-4
L819	3320-146	COIL, FIXED, 0.3 uh	2	2-5
L820		Same as L819		2-5
L821	3320-186	COIL, FIXED, 3.25 uh	2	2-4
L822		Same as L821		2-4
R801	18410-332	RESISTOR, FIXED, COMPOSITION, 33 ohms, 10%, 1/2 W	2	2-5
R802	18410-472	RESISTOR, FIXED, COMPOSITION, 47 ohms, 10%, 1/2 W	8	2-5
R803	18530-23	RESISTOR, FIXED, FILM, 500,000 ohms, 1%, 1/2 W	2	2-5
R804	18530-95	RESISTOR, FIXED, FILM, 1 megohm, 1%, 1/2 W	4	2-5
R805	18530-92	RESISTOR, FIXED, FILM, 750K ohms, 1%, 1/2W	2	2-5
R806	18530-91	RESISTOR, FIXED, FILM, 333,000 ohms, 1%, 1/2 W	2	2-5
R807	18530-4	RESISTOR, FIXED, FILM, 900,000 ohms, 1%, 1/2W	2	2-5
R808	18530-89	RESISTOR, FIXED, FILM, 111,000 ohms, 1%, 1/2 W	2	2-5
R809	18530-93	RESISTOR, FIXED, FILM, 950K ohms, 1%, 1/2 W	2	2-5
R810	18530-87	RESISTOR, FIXED, FILM, 52,600 ohms, 1%, 1/2 W	2	2-5
R811	18530-94	RESISTOR, FIXED, FILM, 975K ohms, 1%, 1/2W	2	2-5

REF. SYMBOL	PART NUMBER	DESCRIPTION	QUANT. PER EQUIP.	LOCATED ON FIGURE NO.
R812	18530-79	RESISTOR, FIXED, FILM, 25,600 ohms, 1%, 1/2W	2	2-5
R813	18530-96	RESISTOR, FIXED, FILM, 990,000 ohms, 1%, 1/2 W	2	2-5
R814	18530-81	RESISTOR, FIXED, FILM, 10,100 ohms, 1%, 1/2 W	2	2-5
R815	18410-102	RESISTOR, FIXED, COMPOSITION, 10 ohms, 10%, 1/2 W	6	2-5
R816	18530-98	RESISTOR, FIXED, FILM, 995,000 ohms, 1%, 1/2 W	2	2-5
R817	18530-83	RESISTOR, FIXED, FILM, 5030 ohms, 1%, 1/2 W	2	2-5
R818		Same as R815		2-5
R819	18530-99	RESISTOR, FIXED FILM, 997,000 ohms, 1%, 1/2 W	2	2-5
R820	18530-85	RESISTOR, FIXED, FILM, 2510 ohms, 1%, 1/2 W	2	2-5
R821		Same as R815		2-5
R822		Same as R801		2-5
R823		Same as R802		2-5
R824		Same as R803		2-5
R825		Same as R804		2-5
R826		Same as R805		2-5
R827		Same as R806		2-5
R828		Same as R807		2-5
R829		Same as R808		2-5
R830		Same as R809		2-5
R831		Same as R810		2-5
R832		Same as R811		2-5
R833		Same as R812		2-5
R834		Same as R813		2-5
R835		Same as R814		2-5
R836		Same as R815		2-5
R837		Same as R816		2-5
R838		Same as R817		2-5
R839		Same as R815		2-5

REF. SYMBOL	PART NUMBER	DESCRIPTION	QUANT. PER EQUIP.	LOCATED ON FIGURE NO.
R840		Same as R819		2-5
R841		Same as R820		2-5
R842		Same as R815		2-5
R843		Same as R804		2-5
R844	18415-102	RESISTOR, FIXED, COMPOSITION, 1 megohm, 10%, 1/2 W	2	2-5
R845		Same as R802		2-4
R846	18433-222	RESISTOR, FIXED, COMPOSITION, 22K ohms, 10%, 2W	2	2-4
R847	18410-272	RESISTOR, FIXED, COMPOSITION, 27 ohms, 10%, 1/2 W	4	2-4
R848	18530-139	RESISTOR, FIXED, FILM, 500 ohms, 1%, 1/2 W,	4	2-3
R849	18552-33	RESISTOR, FIXED, FILM, 5500 ohms, 1%, 1W	4	2-3
R850		Same as R849		2-3
R851	16927-156	POTENTIOMETER ASSY: 2500 ohms, special	2	2-5
R852	18575-224	RESISTOR, FIXED, WIRE WOUND, 8,000 ohms, 5%, 5W	2	2-1
R853	16925-357	RESISTOR, WIRE WOUND, 10K ohms, 2W, 3/8-32 thrd x 3/8" lg FMS, 1/4" dia., screw driver slotted shaft, 2" lg. beyond bushing	2	2-1
R854	40101-253	RESISTOR, VARIABLE, COMPOSITION, 25,000 ohms, 20%, 2W linear taper, 3/8" bushing lgth, 7/8" shaft length FMS, screw driver slot	2	2-1
R855	18414-102	RESISTOR, FIXED, COMPOSITION, 100K ohms, 10%, 1/2W	4	2-3
R856	18423-222	RESISTOR, FIXED, COMPOSITION, 22K ohms, 10%, 1W	2	2-1
R857	18411-562	RESISTOR, FIXED, COMPOSITION, 560 ohms, 10%, 1/2 W	2	2-1
R858		Same as R848		2-3
R859		Same as R802		2-4
R860	18414-152	RESISTOR, FIXED, COMPOSITION, 150K ohms, 10%, 1/2W	4	2-4
R861	16925-341	RESISTOR, VARIABLE, COMPOSITION, dual, 2 x 100K ohms, 20%, 2W 3/8" bushing length, 7/8" shaft lgth FMS, screw driver slot	2	2-1
R862		Same as R860		2-3
R863		Same as R802		2-3
R864		Same as R804		2-5

REF. SYMBOL	PART NUMBER	DESCRIPTION	QUANT. PER EQUIP.	LOCATED ON FIGURE NO.
R865		Same as R844		2-5
R866		Same as R802		2-4
R867		Same as R846		2-4
R868		Same as R847		2-4
R869		Same as R848		2-4
R870		Same as R849		2-3
R871		Same as R849		2-3
R872		Same as R851		2-5
R873		Same as R852		2-1
R874		Same as R853		2-1
R875		Same as R854		2-1
R876		Same as R856		2-1
R877		Same as R855		2-4
R878		Same as R857		2-1
R879		Same as R848		2-3
R880		Same as R802		2-3
R881		Same as R860		2-4
R882		Same as R861		2-1
R883		Same as R860		2-4
R884		Same as R802		2-3
R885	18433-332	RESISTOR, FIXED, COMPOSITION, 33K ohms, 10%, 2W	2	2-3
R886		Same as R885		2-3
R887	18414-222	RESISTOR, FIXED, COMPOSITION, 220K ohms, 10%, 1/2W	2	2-3
R888		Same as R887		2-3
R889	18414-161	RESISTOR, FIXED, COMPOSITION, 160K ohms, 5%, 1/2 W	2	2-4
R890		Same as R889		2-4
R891	18411-102	RESISTOR, FIXED, COMPOSITION, 100 ohms, 10%, 1/2 W	4	2-4
R892		Same as R891		2-4
R893	18414-201	RESISTOR, FIXED, COMPOSITION, 200K ohms, 5%, 1/2 W	2	2-3

REF. SYMBOL	PART NUMBER	DESCRIPTION	QUANT. PER EQUIP.	LOCATED ON FIGURE NO.
R894		Same as R893		2-3
R895	18411-472	RESISTOR, FIXED, COMPOSITION, 470 ohms, 10%, 1/2 W	2	2-3
R896		Same as R895		2-3
R897	18412-472	RESISTOR, FIXED, COMPOSITION, 4700 ohms, 10%, 1/2 W	2	2-3
R898	18423-682	RESISTOR, FIXED COMPOSITION, 68,000 ohms, 10%, 1W	1	2-3
R899		Same as R897		2-3
R900		Same as R891		2-4
R901		Same as R891		2-4
R902	18575-223	RESISTOR, FIXED, WIRE WOUND, 6,000 ohms, 5%, 5W	2	2-1
R903		Same as R902		2-1
R904	18432-392	RESISTOR, FIXED, COMPOSITION, 3900 ohms, 10%, 2 W	1	2-3
R905	18422-562	RESISTOR, FIXED, COMPOSITION, 5600 ohms, 10%, 1 W	1	2-3
R906		Same as R855		2-5
R907		Same as R855		2-5
R908	16925-342	RESISTOR, VARIABLE, COMPOSITION, dual, 2 x 100K ohms, 20%, 2W screw driver slot, 1/4" bushing length, 3/8" shaft length FMS	1	2-4
R909	18577-158	RESISTOR, WIRE WOUND, 400 ohms, 1%, 1/2 W	2	2-4
R910		Same as R909		2-4
R911	18422-182	RESISTOR, FIXED, COMPOSITION, 1800 ohms, 10%, 1W	1	2-3
R912	18422-821	RESISTOR, FIXED, COMPOSITION, 8200 ohms, 5%, 1W	4	2-5
R913		Same as R912		2-5
R914		Same as R912		2-5
R915		Same as R912		2-5
R916		Same as R847		2-1
R917	18575-228	RESISTOR, FIXED, WIRE WOUND, 3,000 ohms, 5%, 5W	1	2-3
R918		Same as R847		2-4
R919	18433-152	RESISTOR, FIXED, COMPOSITION, 15K ohms, 10%, 2W	1	2-3

REF. SYMBOL	PART NUMBER	DESCRIPTION	QUANT. PER EQUIP.	LOCATED ON FIGURE NO.
R920	18412-301	RESISTOR, FIXED, COMPOSITION, 30K ohms, 5%, 1/2 W	2	2-3
R921	18575-408	RESISTOR, FIXED, WIRE WOUND, 20K ohms, 10%, 10W	2	2-1
R922		Same as R921		2-1
R923	18413-122	RESISTOR, FIXED, COMPOSITION, 12K, ohms, 10%, 1/2 W	1	2-4
R924	18411-911	RESISTOR, FIXED, COMPOSITION, 910 ohms, 5%, 1/2 W	2	2-4
R925		Same as R924		2-4
S801	19912-390	SWITCH, ROTARY, 2 wafer, 9 position (volts/CM) (concentric with 16925-353) ceramic	2	2-4
S802	19911-68	SWITCH, SLIDE, SPDT, 0.6A, 125V, 11/32" black trigger, 0.140 dia mtg holes	2	2-2
S803	19912-391	SWITCH, ROTARY, 1 wafer, 2 position (polarity) phenolic	2	2-1
S804	19912-489	SWITCH, ROTARY, 3 wafer, 5 position (mode) phenolic	1	2-4
S805		Same as S301		2-4
S806		Same as S802		2-2
S807		Same as S803		2-1
V801	20877-11	TUBE, 12AT7	2	2-1
V802	20875-51	TUBE, 6AL5	1	2-1
V803		Same as V801		2-1
V804	20875-77	TUBE, 12AT7	2	2-1
V805	20875-73	TUBE, 6AK5	2	2-1
V806	20877-13	TUBE, 12AU6 (paired)	2 pair	2-1
V807		Same as V806		2-1
V808	20877-12	TUBE, 6AU6 (paired)	2 pair	2-1
V809		Same as V808		2-1
V810		Same as V805		2-1
V811		Same as V806		2-1
V812		Same as V806		2-1
V813		Same as V808		2-1
V814		Same as V808		2-1
V815		Same as V804		2-1
XV801	19350-298	SOCKET, BOTTOM MTG MICA FILLED PHENOLIC 4 ground lugs	4	2-1

REF. SYMBOL	PART NUMBER	DESCRIPTION	QUANT. PER EQUIP.	LOCATED ON FIGURE NO.
XV802	19350-299	SOCKET, 7 pin, miniature, bottom mtg, mica filled phenolic 4 ground lugs	3	2-1
XV803		Same as XV801		2-1
XV804		Same as XV801		2-1
XV805		Same as XV802		2-1
XV806	19350-300	SOCKET, 7 pin miniature, top mtg, mica filled phenolic	8	2-1
XV807		Same as XV806		2-1
XV808		Same as XV806		2-1
XV809		Same as XV806		2-1
XV810		Same as XV802		2-1
XV811		Same as XV806		2-1
XV812		Same as XV806		2-1
XV813		Same as XV806		2-1
XV814		Same as XV806		2-1
XV815		Same as XV801		2-1